Intl. Partners: Centro de Astrobiologia (CAB)

NAI International Associate Member: Centro de Astrobiología
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The Centro de Astrobiología is a transdisciplinary centre with 9 laboratories: Molecular Evolution, Bacterial Evolution, Extremophiles, Molecular Ecology, Bioinformatics, Planetary Geology, Robotics and Planetary Exploration, Advanced Computing and Simulation and Transdisciplinary. These laboratories have the common objective of studying the origin and evolution of Life and its distribution in the Universe to answer the question "What is life?".

1. Planetary Evolution

Study of large scale properties of a incompressible fluid in rotation with random fluctuations using the renormalization group tools to simulate the formation of protoplanetary disks.

Scanning the minerals detected in chondrules and in the matrix of different chondrites belonging to the Museo Nacional de Ciencias Naturales by scanning electronic microscopy, electronic miscroscopy and PIXE has been performed on.

Raman spectroscopy has been used to study both fragments from the Allende carbonaceus chondrite and from the Nakhla martian meteorite.

CAB participates in the IMPACT program of the European Science Foundation and was working in the meteoritic impact of El Gasco studying the petrology, mineralogy and geochemical features of the outcrop.

The process of hydrothermal mineralization is a topic of high interest due to the potential liaison with Marte. The Canary Island have been identified as quite interesting area (Tenerife North), as well as the Decepcion Island (Antartic), where submarine hydrothermal emissions were sampled.

In the field of ultraviolet radiation, a model of radiative transference has been established to evaluate biological damage and the potential of protective environmental mechanisms.

2. Evolution of Life

One of CAB's research is the study of the evolution of biological fitness in viral populations after bottle neck passages (population is reduced to one or several virus particles).The results with foot−and−mouth disease viruses show that fitness first decreases but eventually attains a constant mean value. A

theoretical model has been developed which perfectly predicts this biphasic dynamics.

The study of the population dynamics of genetic polimorphisms and molecular memory in viral quasispecies is another research line, based on the sequence of molecular clones and DNA microarray technology . This study is grounded in the recent discovery that molecular memory in quasispecies of RNA viruses possess a molecular memory of their past evolutionary history in the form of minority genomes that dominate the mutant population. In this area, some theoretical models have been set up to study the duration and fitness−dependence of memory in two species systems (wild type and mutant).

Another line of research is the influence of metallic cations on the efficiency and fidelity of the DNA amplification process utilized by the *Taq polymerase* during enzyme polymerase chain reaction (PCR). This a good system to study the effect of several mutagenic stresses in DNA evolution.

Microarray containing more than 10.000 different spots with DNA fragments from *L.ferrooxidans*. This is the result of two overlapping images obtained from gene expression under two different conditions.

DNA repetitive sequences exhibit astrong level of instability, undergoing addition or deletion of repeated unit (dynamic mutations) and it is assumed that replication slippage error could be involved in some way in such mutation. An *in−vitro* experimental system has been set up to study the capacities of different DNA polymerases for undergoing slippage errors. The main result is the identification of the high frequency of slippage error during DNA amplification by PCR.

Protein evolution is another topic analyzed through its thermodynamic preservation. The following investigations have been carried out: I) simulation of protein folding , ii) simulation of protein neutral evolution to identify thermodynamic preservation over molecular evolution, iii) trade off between the thermodynamic properties of different homologous bacteria , iv) development of a automatic system for prediction and evaluation of 3D protein structures.

Genome organization in species from unicellular eucariots to complex multicelullar organisms, with special emphasis on plants and algas, have been investigated. The main research activity has been focused in a diatomea (*Phaedodactylum tricornutum*) since this organism is common in many ecosystems.

3. Life in Extreme Conditions

The Tinto River is an interesting model of life in extreme conditions due mainly to the low pH and the high concentrations of heavy metals, consequences of the metabolic activity chimolithotrophic microorganisms who thrive in the

Spanish Pyritic Belt.

To study the biodiversity, methodologies from both conventional and molecular biology have been used. Specific probes for in *situ* hybridation have been developed for quantification of the chemolithotrophic activity in the prokaryotes responsible for the extreme conditions of the system. The eukaryotic diversity is being studied using conventional isolation methods and molecular ecology (DGGE, dying) techniques. Mechanisms of adaptation to the extreme conditions are being identified and studied. The metal resistance profile for different filamentous fungi has been evaluated and a characterization of the mechanisms allowing growth in the presence of high concentrations of Cr (III) and As(V) is in progress.

Leptospirillum ferrooxidans is a Gram−negative acidophilic bacterium able to thrive in acidic water with high metal concentrations (copper, zinc, uranium, etc), like those in the Tinto river. Its way of life is one of the most primitive extant on Earth, and it is primarily responsible for maintaining the pH balance and hence the physico−chemical properties of the ecosystem. However, very little is known about the molecular bases of its metabolism. DNA microarrays is a well suited technology for performing gene expression analysis to identify the genes involved in such processes, because thousands of DNA probes can be assessed simultaneously.

Top view of Snorkel during the developments tests, showing the three modules and the upper propellers.

All fragments (4.500) from an *L.ferrooxidans* genomic library have been printed on a chip. Gene expression analysis has been completedand the total RNA of *L.ferrooxidans* isolated from pure cultures under different nutritional and stress conditions. Our results are very promising and show that this system works very well. We have sequenced and identified some genes involved in the simplicity of *L.ferrooxidans* way of life (iron and nitrogen metabolisms). Further characterization and regulation of these genes, as well as its evolutionary implications, will be studied.

The CAB is a member of the MASSE (Miniaturised Assays for Solar System Exploration) working group led by Dr. D. McKay , which has the objective of developing technology to detect biomarkers. The Center is in charge of tuning the methodology for using microarrays in this project.

4. Technology and Instrumentation

The first model of the Triton probe has been finished. It is a low pH resistant cylinder with a suit of sensors to measure pH, conductivity, dissolved oxygen with a motorized zoom camera and an external lighting system. A set of four motorized syringes have been allocated on the Triton's external surface to collect water samples. The whole the system is controlled remotely by a teleoperator and all the measurements visualized in real time by the scientist. Triton has been operated successfully in an artificial lake located at the Tinto sources.

Snorkel, a remotely operated underwater vehicle, was also finished during this period. Like Trion, it is designed to operate in a low pH environment, able to operate up to 50 mm deep; its design is modular, with a central element containing all the control, power, communication and a computer system, a third interchangeable module is used to implement different scientific payloads. Preliminary tests have been conducted in a small lake on the INTA campus.

In the field of instrumentation, the development of a portable microscope−Raman spectrometer has been launched. A laboratory prototype has been built with results comparable to commercial products; this first design has been used to study meteorites. The other emphasis is on the design of a differential optical absorption spectrometer for the study of atmospheric aerosols.

CAB is involved in the Beagle 2 mission through the calibration of the UV sensors installed in the Environmental Sensor Suit.

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